



AIRS Science Team Meeting

SNPP Sounder SIPS Status and Highlights

Ruth Monarrez

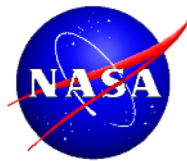
Sounder SIPS Manager

Jet Propulsion Laboratory, California Institute of Technology
4800 Oak Grove Dr., Pasadena, CA 91109

Bruce Vollmer and Mike Theobald

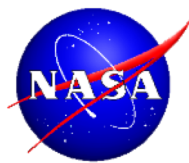
GES DISC Manager and GES DISC Lead Engineer
NASA Goddard Space Flight Center

April 3, 2019



A word about the Sounder SIPS

- **The SNPP/JPSS Sounder SIPS consists of two elements: JPL & GES DISC**
 - Science Algorithm Integration, Test & Validation – JPL
 - Integration of code from Science Teams into our data system to ‘execute on demand’ in a production-like environment
 - Development of production-level PGEs which are sent to GES DISC to put into operations
 - Product definition lead (coordinated effort): metadata, attributes, units
 - Documentation: writing of Product User Guides and review of ATBDs
 - Production of test products for assessment
 - Assessment and feedback to PIs of retrieval algorithms (Bjorn Lambrigtsen’s team)
 - Data Product Generation (Operations) – GES DISC
 - Ingestion and distribution of SNPP & JPSS-1 Level 0 data
 - Forward processing and reprocessing of research NASA sounder products from SNPP and JPSS-1: Level 1 – Level 3
 - Documentation Review
 - Acquisition of ancillary products needed to support data processing
 - Distribution of Level 1, Level 2, Level 3 products to JPL via subscription



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A word about the Sounder SIPS con't

- **Data Archive and Distribution**
 - SNPP Sounding data: Goddard DAAC
 - Provide a full suite of user services for distribution:
 - Data subscriptions
 - Ordering capabilities
 - Subsetting
- **Points of Contact**
 - JPL – Ruth Monarrez (ruth.monarrez@jpl.nasa.gov)
 - GES DISC – Bruce Vollmer and Mike Theobald
 - General SIPS or ATMS L1 questions: sounder.sips@jpl.nasa.gov
 - CrIS Level 1 team: cris.l1b.support@ssec.wisc.edu

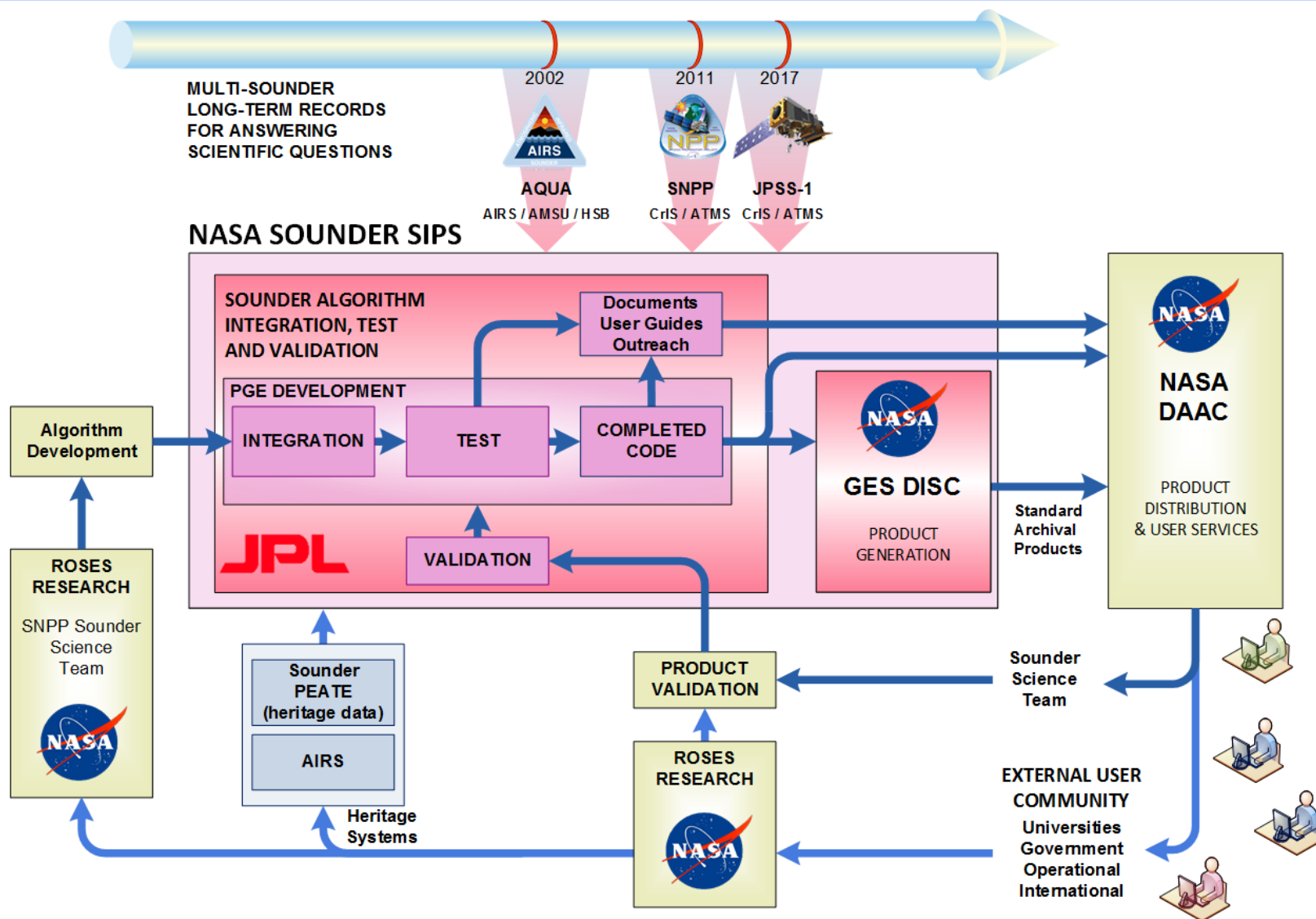
- **The Sounder SIPS works closely with:**
 - **NASA Sounding Science Team**
 - Overall direction coordinated with the SNPP Sounder Discipline lead, Chris Barnett
 - Coordination support through our Sounder Science Team liaison, Eric Fetzer
 - Retrieval system support from revolving Sounding Science Team members
 - **CrIS Level 1 Algorithm Team (Univ of Wisc)**
 - Joe Taylor (PI, UW) and Larrabee Strow (PI, UMBC)
 - Graeme Martin (Technical Manager)
 - **ATMS Level 1 Algorithm Team (JPL)**
 - Bjorn Lambrigtsen (PI), Evan Fishbein, Mathias Schreier
 - **AIRS Project**
 - Joao Teixeira (AIRS PI), Tom Pagano (AIRS Project Manager)
 - Algorithm and code sharing (where it makes sense)
 - Shared resources: hardware, software, personnel
 - Product assessment by AIRS Science Team
 - **Earth Science Data and Information System (ESDIS) Project**
 - NASA SIPS Guidance - John Moses & Jeanne Behnke

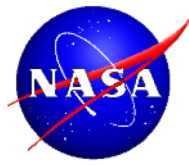


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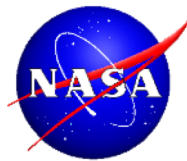
Functional Interfaces





Sounder SIPS Requirements Summary

- Develop and/or integrate PGEs delivered by Science Team Members
- Production of Level 1, 2 and 3 data products from SNPP Sounding instruments: ATMS and CrIS
- **Support the Sounder Science Team in data validation activities**
- Document and deliver source code, executables, user guide and ATBDs to the GES DISC for long-term storage and access
- All Sounder SIPS products will be produced in accordance to the NASA data policy (<https://science.nasa.gov/earth-science/earth-science-data/data-information-policy>)



L2 Retrieval Systems

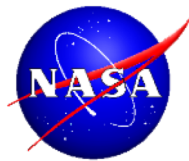
- **Retrieval Systems supported at Sounder SIPS/JPL**
 - Delivered and Integrated:
 - **C**limate-oriented **H**eritage **A**IRS **R**etrieval **T**echnique (CHART) - GSFC
 - **C**ommunity **L**ong-term **I**nfrared **M**icrowave **C**oupled **A**tmospheric **P**roduct **S**ystem (CLIMCAPS) – STC
 - ESSPA-TraceGas: Amonia (HN_3) Retrieval – AER
 - **R**etrieval **A**lgorithm for **M**icrowave **S**ounders in **E**arth **S**cience– JPL
 - Still to be delivered and integrated:
 - **E**arth **S**ystem **S**cience **P**rofiling **A**lgorithm (ESSPA) – AER
- **Retrieval Systems to be delivered and installed at Sounder SIPS/GES DISC**
 - **C**ommunity **L**ong-term **I**nfrared **M**icrowave **C**oupled **A**tmospheric **P**roduct **S**ystem (CLIMCAPS) – STC
 - ESSPA-TraceGas: Amonia (HN_3) Retrieval – AER
 - **R**etrieval **A**lgorithm for **M**icrowave **S**ounders in **E**arth **S**cience (RAMSES) 2 – JPL

TASNPP Sounder SIPS Support

TERRA, AQUA and SUOMI-NPP Awardees

Additional retrievals / research to be supported:

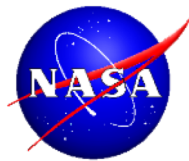
PI	Affiliation	Instruments	ROSES Topic
Barnet, Chris	STC	AIRS/AMSU CrIS/ATMS	CLIMCAPS: Sounder core algorithm
Cady-Pereira, Karen	AER	CrIS	Ammonia (NH ₃) Alg
Elsaesser, Gregory	Columbia	AIRS L2	Deep Conv. Clouds
Henze, Daven	U.Colo.	CrIS	NH3 Inv. Model
Huang, Xianglei	U.Mich.	AIRS, CERES, CrIS	cloud radiative effect
Lambrigtsen, Bjorn	JPL	AMSU, ATMS	ATMS L2
Liu, Xu	LaRC	AIRS/AMSU CrIS/ATMS	CLARREO Climate Fingerprinting
Milstein, Adam	MIT/LL	AIRS, CrIS	NN L2 alg
Payne, Vivienne	JPL	CrIS	PAN
Reale, Oresete	USRA	AIRS, CrIS L2	R, CCR DA
Santek, David	U.Wisc	AIRS, CrIS L2	H2O, O3 winds
Soden, Brian	U.Miami	AIRS, CERES, MODIS	radiative kernels to quantify CMIP6 fluxes
Strow, Larrabee	UMBC	AIRS, CrIS, IASI	Climate trends
Tian, Baijun	JPL	AIRS/AMSU	CMIP5/6
Worden, Helen	UCAR	MOPITT, CrIS	Carbon Monoxide (CO)
Ruston, Benjamin	NRL	AIRS, CrIS, CALIOP, MODIS, MISR	dust correction within R DA
Tan, Ivy	UMBC	MODIS, AIRS, CERES, AMSR	cloud feedback



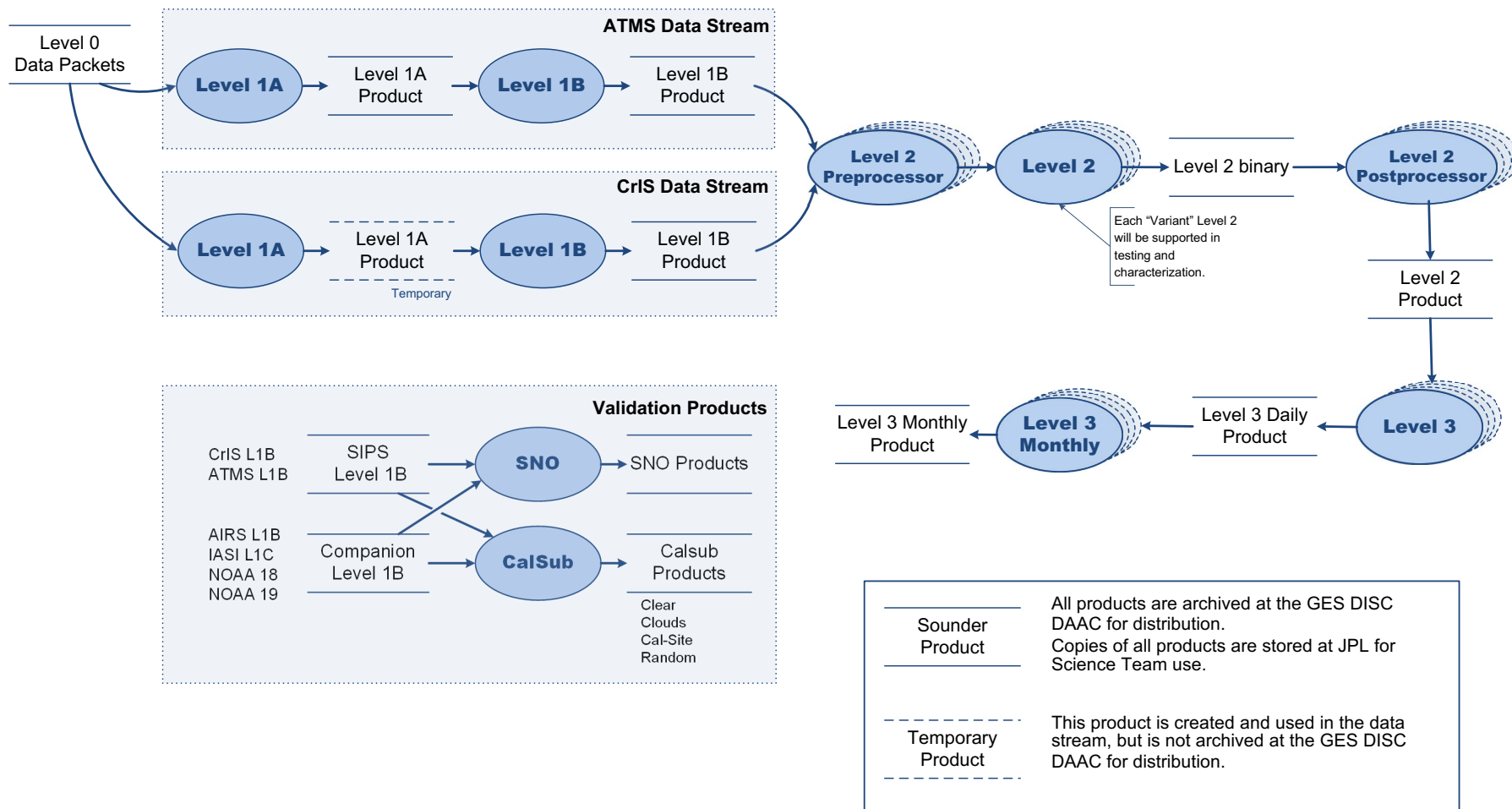
Sounder SIPS Product Specification

- **Data Product Specifications (SounderCDF)**
 - All products will be formatted to conform to netCDF-4 / HDF 5 specification
 - Product metadata will conform to the Climate and Forecasting (CF), Attribute Conventions for Data Discovery (ACDD) guidelines and ISO 19115 Standard
 - Granule Sizes:
 - Level 1B ATMS and CrIS: 6-minute granules
 - Level 2: 6-minute granules, matching CrIS & ATMS granules
 - Level 3 Daily: Gridded global data
 - Two groups: ascending and descending
 - $1^\circ \times 1^\circ$ gridded data.
 - Level 3 Monthly products follow same pattern as daily
 - Daily Granule Maps
 - SNO and CalSub will continue to be RTP3* format temporarily (refactoring to “SounderCDF” netCDF4/HDF5 format)

*RTP3 developed by the Sounder PEATE



Sounder SIPS Data Flow



Sounder SIPS Products to date

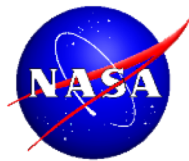
Processing at Sounder SIPS/GES-DISC:

Level 1	Version 1	Coverage	Public Release
ATMS	L1B	Entire mission	March 1, 2017
CrIS	L1B	Entire mission up to V2	March 1, 2017 (NSR) Aug 3, 2017 (FSR)

Processing stopped Jan 31, 2019

Level 1	Version 2	Coverage	Public Release
SNPP ATMS	L1B*	Entire mission	Spring 2018
SNPP CrIS	L1B*	Entire mission (FSR starting Nov 2, 2015)	Spring 2018
JPSS-1 ATMS	L1B*	Entire mission	January 2019
JPSS-1 CrIS	L1B*	Entire mission (FSR)	April 2019

* - currently being processed at GES DISC



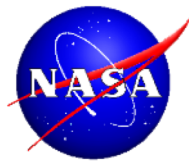
Sounder SIPS Products to date (con't)

Processing at Sounder SIPS/JPL:

Level 2/3	Version 1	Coverage Jan, April, July, Oct: 2013, 2015	Public Release
CrIMSS	CHART	X	Spring 2019
	CLIMCAPS	X	Spring 2019
	ESSPA*	X	Late Summer 2018
	ESSPA-NH3	X	Spring 2019
ATMS	RAMSES 2	X	Spring 2019

* - awaiting code delivery

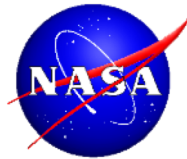
Products will be sent to GES DISC for archiving and distribution.



Sounder SIPS Products to date

Processing at Sounder SIPS/GES DISC:

Level 2/3	Version 2	Coverage Full Mission	Public Release
CrIMSS	CLIMCAPS	X	Late Summer / early Fall 2019
	ESSPA-NH3	X	Late Summer / early Fall 2019
ATMS	RAMSES 2	X	Late Summer / early Fall 2019



Data Reprocessing Plans

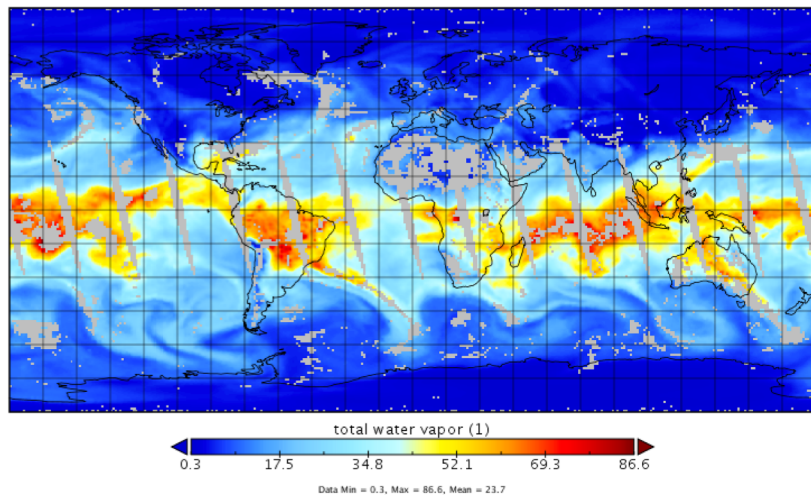
- **Reprocessing Plans**

- Full-mission processing of L2 & L3 with Level 2 algorithm:
 - CrIMSS: CLIMCAPS
 - ATMS: RAMSES 2
- Full-mission reprocessing with major release of software that includes significant science code changes/improvements
- Failed Granules: a fix may be put into forward processing and failed granules will be reprocessed. In this case, the version in the filename of the reprocessed granules will match the other products but internal metadata will indicate the correct software version. Ex: product_version = v02_01_00 will become v02_01_01 but the filename will rem

L3

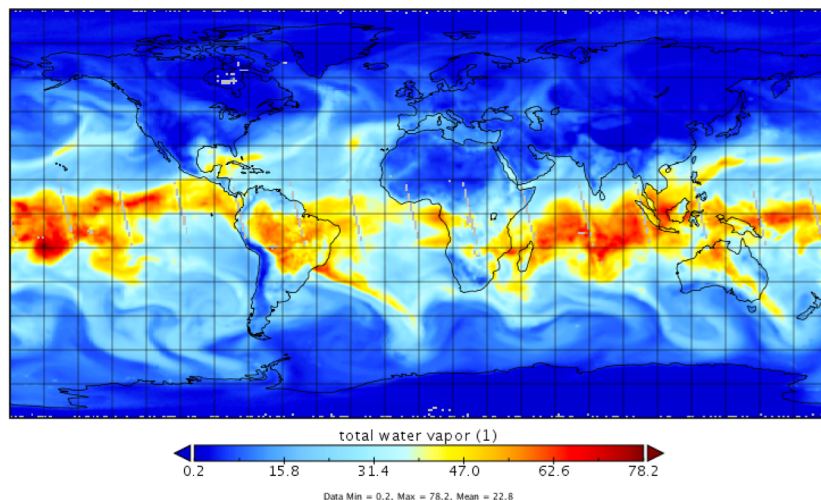
total water vapor

CLIMCAPS

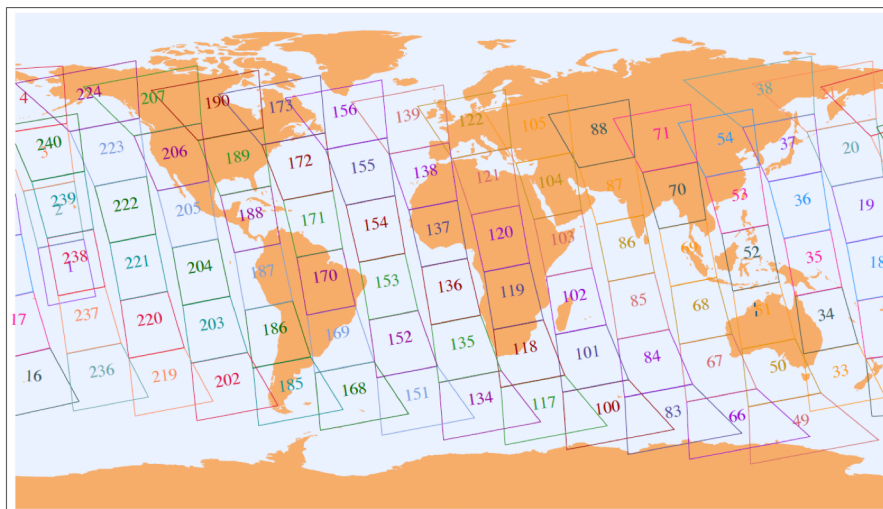


total water vapor

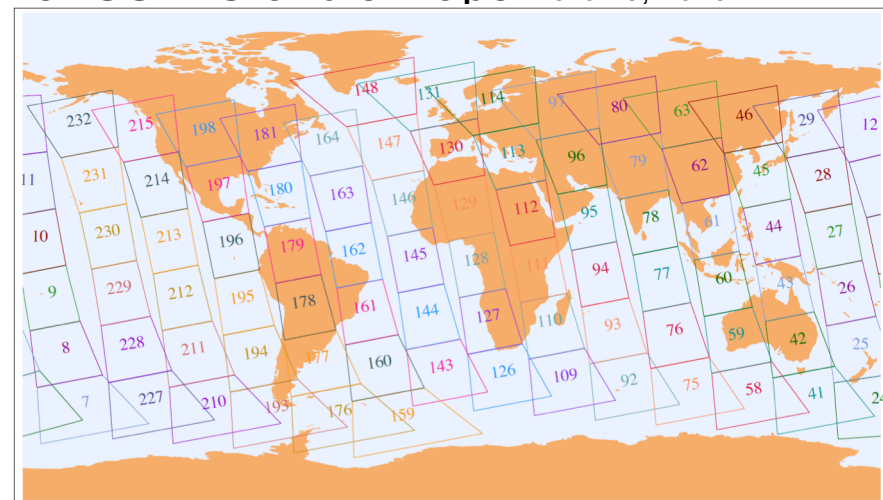
RAMSES 2



SNPP Granule Maps March 3, 2019

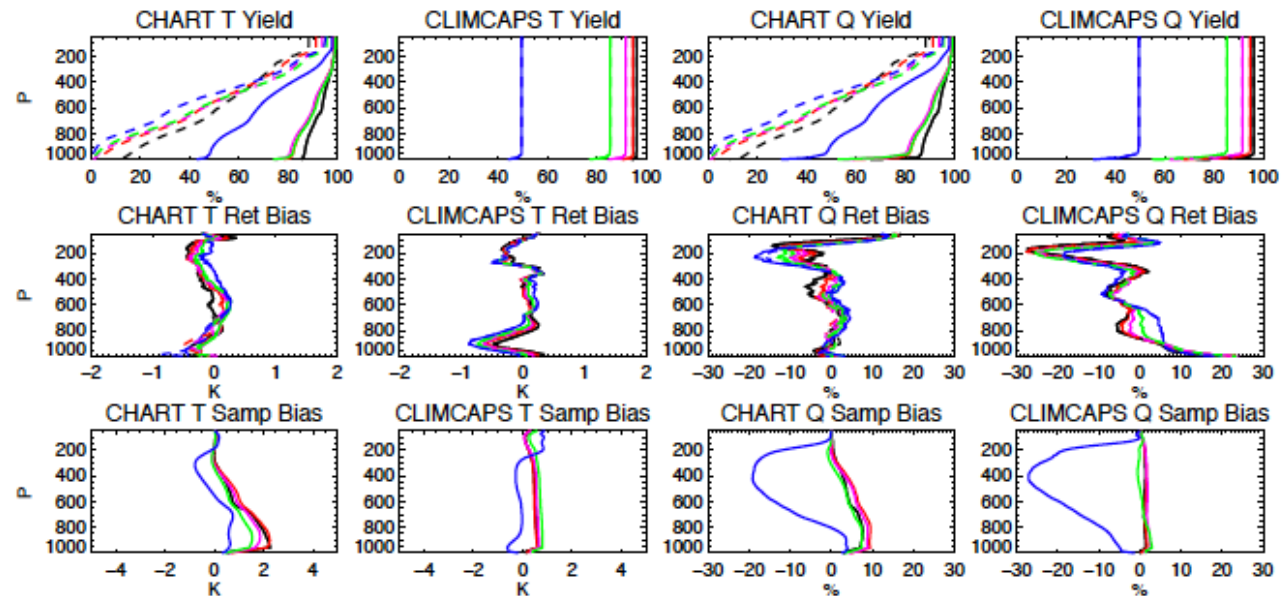
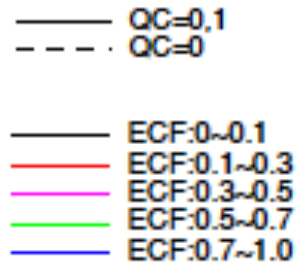


JPSS-1 Granule Maps March 3, 2019

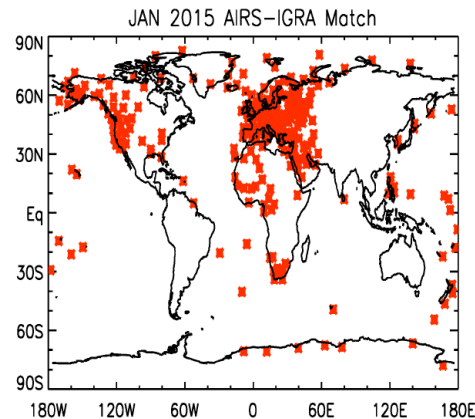


CrIMSS Initial Product Testing & Characterization by JPL AIRS Team

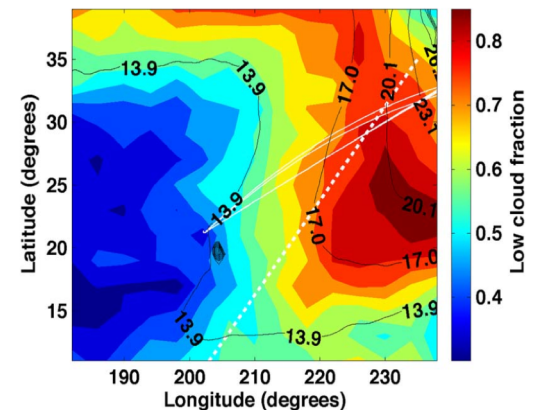
- Comparison with reanalysis
 - Pixel-scale collocation
 - Yield and Quality control
 - Bias analysis



- Comparison with radiosonde
 - Pixel-scale collocation
 - Over land: IGRA
 - Over ocean: MAGIC
 - Field campaigns targeting various climate regimes



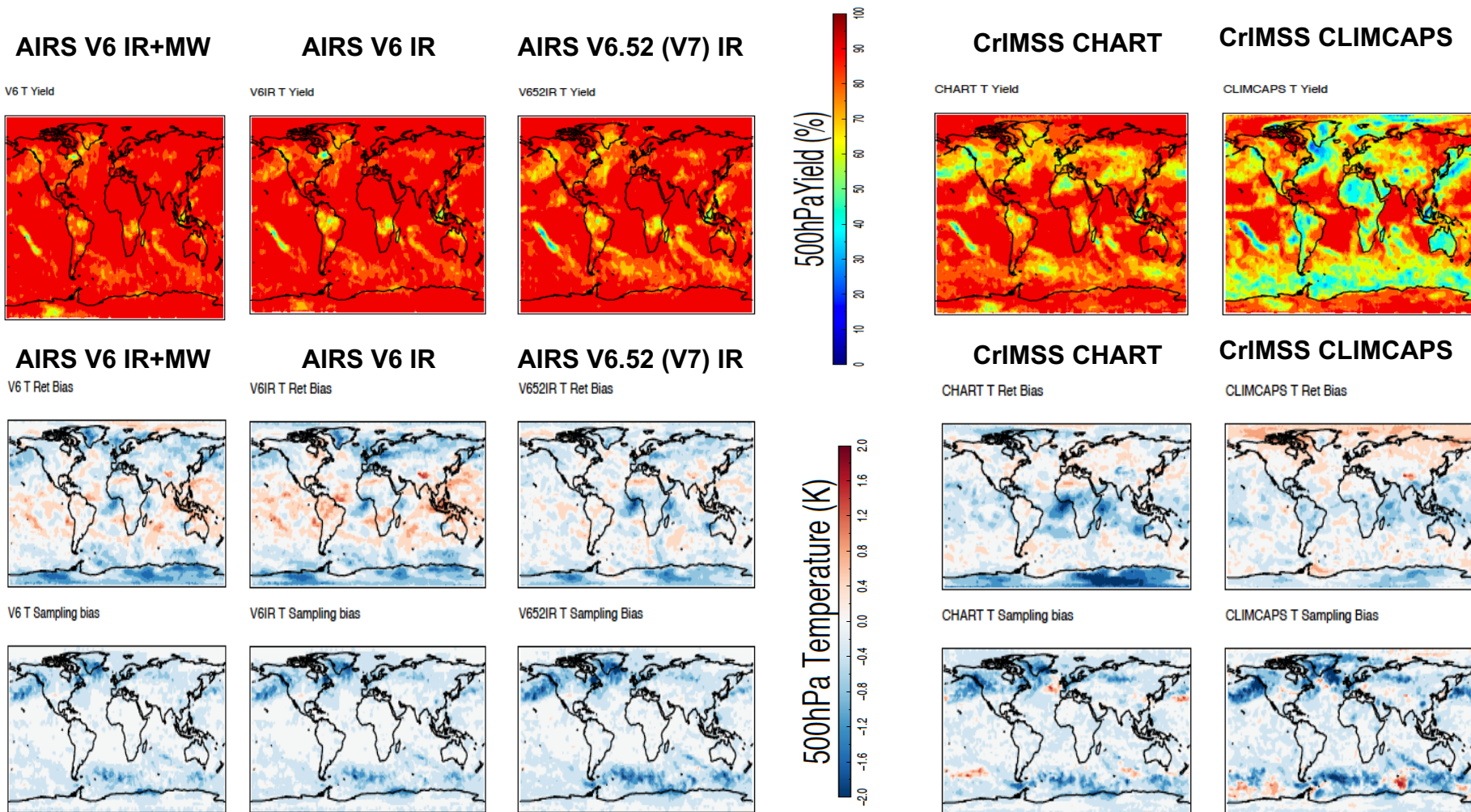
Location of collocated IGRA sondes

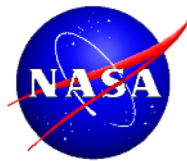


White lines:
MAGIC
shiptracks
between LA
and Hawaii

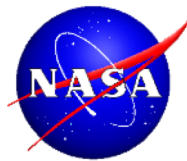
CrIMSS Initial Product Testing & Characterization by JPL AIRS Team (con't)

- AIRS and CrIMSS 500 hPa Temperature Retrieval Yield, Retrieval Bias, and Sampling Bias Against Collocated ECMWF



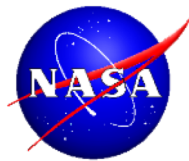


- **In the next 5 – 10 years, where will the Sounder SIPS be ...**
- **Have continuity between AIRS and CrIS products**
 - Level 2 algorithms will be handling both CrIS and AIRS
- **Infrastructure at Sounder SIPS/JPL continues to mature to seamlessly support ongoing missions with similar instruments**
 - We have defined formats that accommodate future sounding instruments
 - Grow our archive with additional products to cross reference JPSS products as well as other sounders
 - Table-driven architecture allows for effortless growth in PGE & products: integration of future retrieval algorithms
- **Conduct a cloud trade study to determine if it's feasible and cost-effective to take advantage of elastic processing resources to support future reprocessing campaigns**



Evolution (cont'd)

- **Have continuity with J1, J2, J3**
 - Level 2 algorithms are designed to be adaptable to the sounding instruments on future platforms provided they are similar
 - Continue creating Calibration Subsets, Simultaneous Nadir Observations and Matchups to track instrument performance
 - **CalSub** is a focused subset of L1 data which makes it easy to compare, say, clear scenes from one instrument to clear scenes from another.
 - **SNOs** are near-simultaneous observations from two instruments, which are used in direct comparisons to assess instrument differences.
 - **Matchups** are subsets of observations matched to correlative data so each instrument can be similarly compared to “truth”.
- **Challenges:**
 - Coordinating support for several algorithms and their nuances



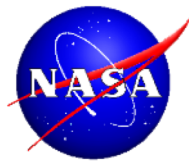
Product Stewardship

	ATBD	User Guide	Report
ATMS L1B	X	X	Science Assessment
CrIS L1B	X	X	Science Assessment
CHART	X	X	Science Assessment
CLIMCAPS	X	X	Science Assessment
ESSPA	X	X	Science Assessment
ESSPA-TraceGas	X	X	Science Assessment
RAMSES 2	X	X	Science Assessment
Project Docs: Data Mngmt Plan ICD Requirements Task Plan			

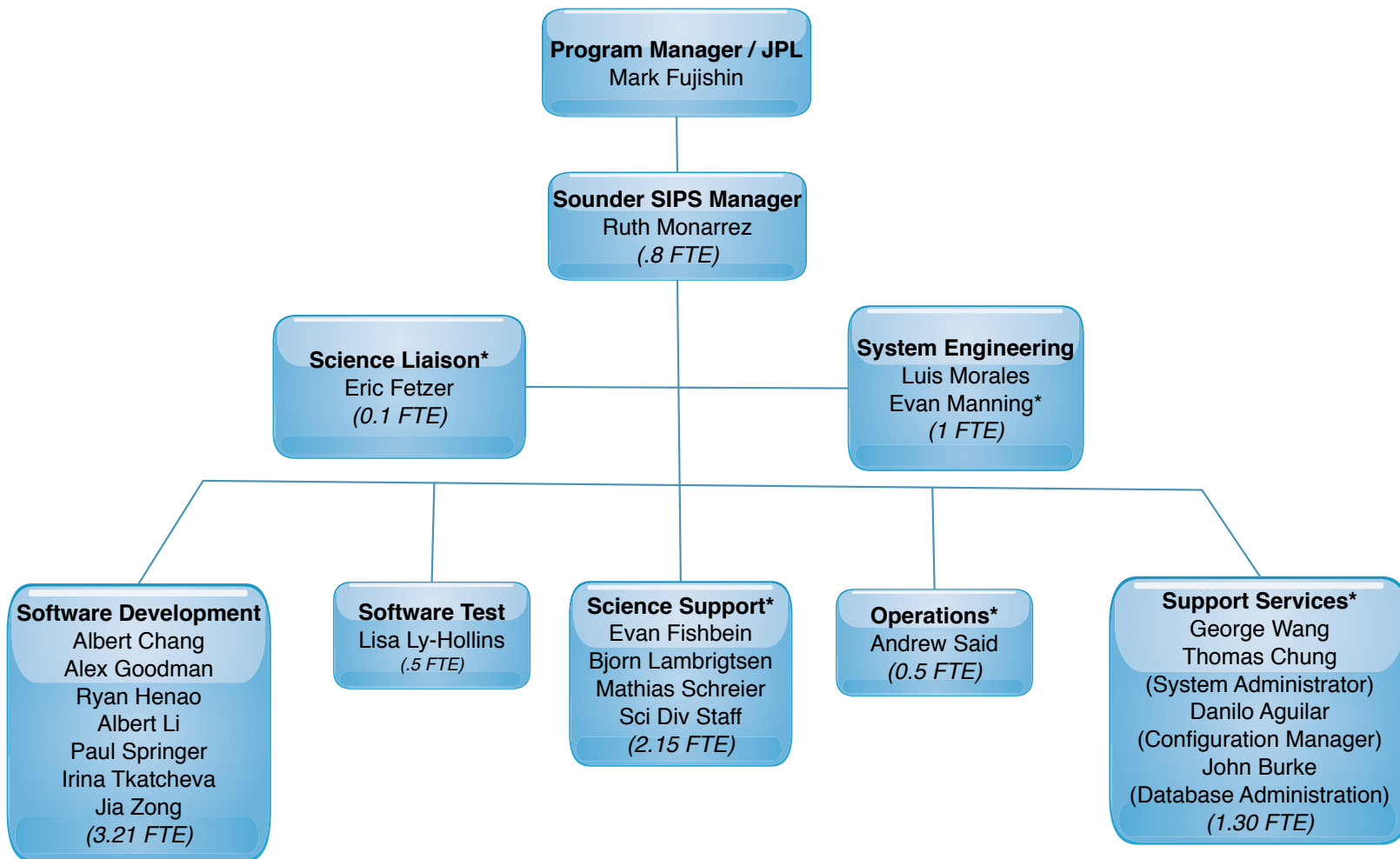
ATBD: responsibility of each PI

User Guides: Lead by Sounder SIPS with input from PI

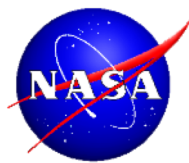
Science Assessment: Sounder Science Team



Sounder SIPS Organization (JPL)



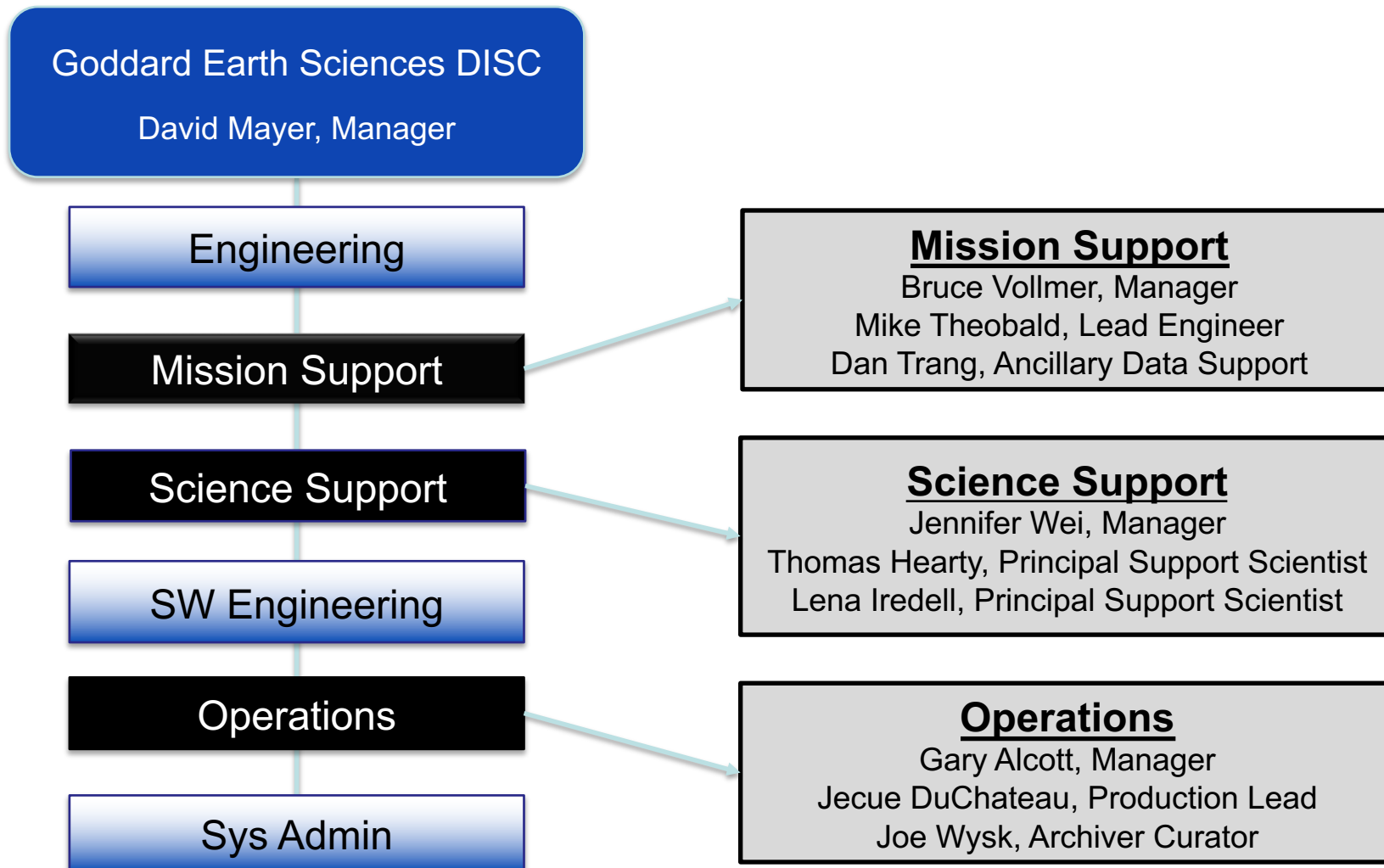
* - Support Sounder SIPS and AIRS project

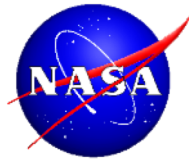


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Sounder SIPS Points of Contact (GSFC)



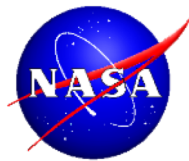


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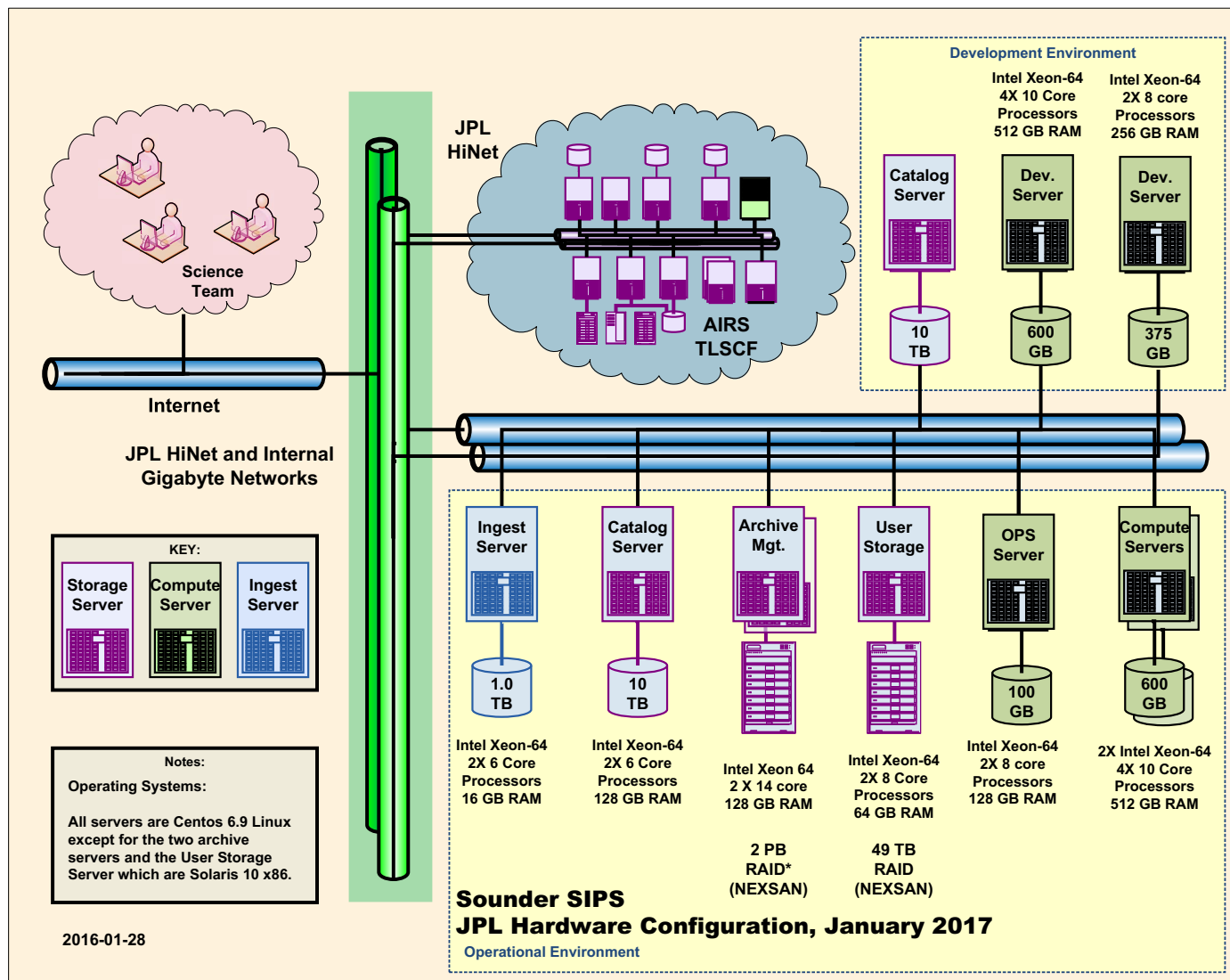
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THAT'S ALL FOLKS!

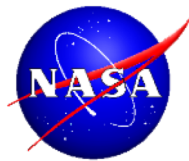
BACKUP SLIDES



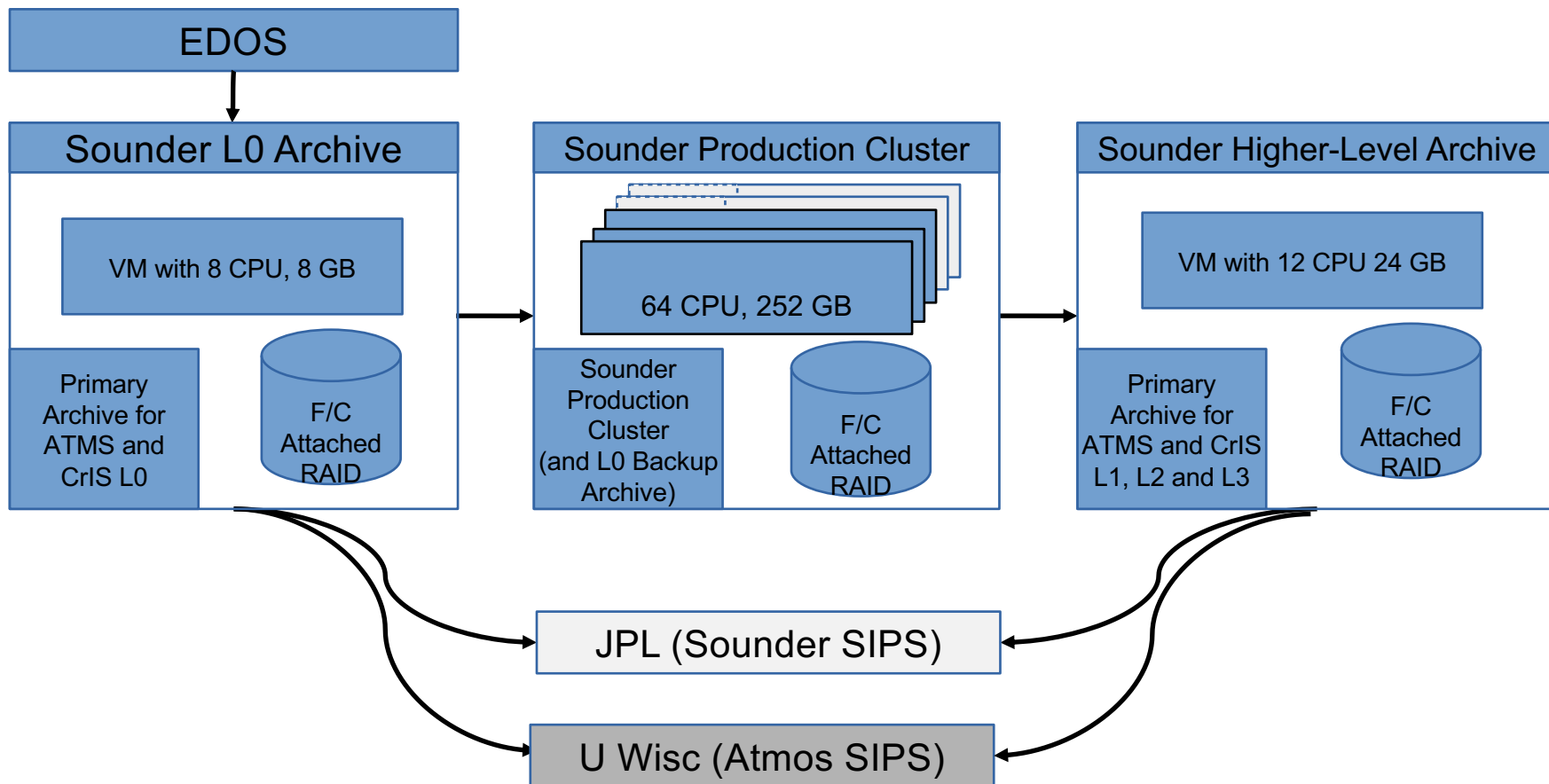
Sounder SIPS Hardware (JPL)

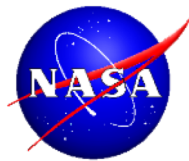


Archive:
Increased from
640 TB to 2 PB



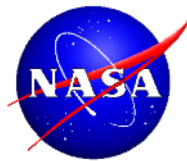
Sounder SIPS Hardware (GES DISC)





Key Milestones & Schedule

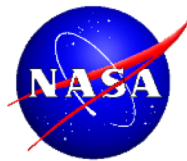
- **Sounder SIPS ATMS & CrIS Level 1 Key Milestones**
 - SNPP Level 1 ATMS and CrIS NSR
 - Beta release – March 2016 (to SNPP Sounder ST, no public release)
 - V1 Release – March 1, 2017 (public release)
 - V2 Release – Spring 2018
 - SNPP Level 1 CrIS FSR
 - Beta Release of products – April 2017 (internal release)
 - V1 Release – Aug 3, 2017
 - V2 Release – Spring 2018
 - JPSS-1 Level 1 CrIS FSR
 - Beta Release of products – March 2018 (internal release)
 - V2 Release – February 2019



Key Milestones & Schedule (cont'd)

- **Sounder SIPS Level 2 Key Milestones.**
 - Process 8 months of data of each Level 2 algorithm and make publically available
 - Level 2 / 3
 - CHART (owner: Joel Susskind)
 - Integrate, validate & iterate algorithm at JPL – Summer 2016
 - Process data for public release V1 Level 2 products – April 2019
 - V1 release to GSFC GES DISC – May 2019
 - CLIMCAPS (owner: Chris Barnet)
 - Integrate, validate & iterate algorithm at JPL – Winter 2017
 - Process data for public release V1 Level 2 products – April 2019
 - V1 release to GSFC GES DISC – May 2019

CHART: Climate Heritage AIRS Retrieval Technique
CLIMCAPS: Community Longterm Infrared Microwave
Coupled Atmospheric Processing System



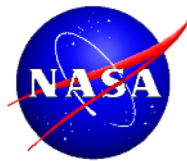
Key Milestones & Schedule (cont'd)

- **Sounder SIPS Level 2 Key Milestones.**
 - ESSPA (owner: Jon Luc Moncet)
 - Integrate, validate & iterate algorithm at JPL – Spring 2019
 - Process data for public release V1 Level 2 products – Late Summer 2019
 - V1 release to GSFC GES DISC – Fall 2019
 - Amonia Level 2 Algorithm (owner: Karen Cady-Pereira)
 - Integrate, validate & iterate algorithm at JPL – Fall 2018
 - Process data for public release V1 Level 2 products – Spring 2019
 - V1 release to GSFC GES DISC – Late Summer 2019
 - RAMSES 2 Level 2 Algorithm (owner: Bjorn Lambrigtsen)
 - Integrate, validate & iterate algorithm at JPL – February 2019
 - Process data for public release V1 Level 2 products – Spring 2019
 - V1 release to GSFC GES DISC – Late Summer 2019

L2 Retrieval Systems (con't)

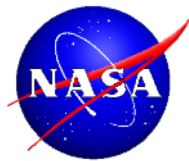
Summary of Level 2 Algorithms to be studied as part of NPP Science Team Activities

PI	<u>Lambrigtsen</u>	Susskind (CHART)	Barnet (CLIMCAPS)	<u>Moncet/Lipton</u> (ESSPA)	Cady-Pereira (ESSPA-TraceGas)
Affiliation	JPL	GSFC	STC	AER	AER
Funding	NPP	NPP	NPP	NPP	NPP
ATMS	ATMS FOV	<u>CrIS FOR</u>	<u>CrIS FOR</u>	<u>CrIS FOR</u>	n/a
<u>CrIS</u>	n/a	<u>CrIS FOR</u>	<u>CrIS FOR</u>	<u>CrIS FOR</u>	<u>CrIS FOV</u>
Regularization	O-E	SVD	O-E	O-E	O-E
Alg. Type	Sequential	Sequential	Sequential	Simultaneous	Sequential
Alg. Heritage	AIRS ST	AIRS ST	AIRS ST v5.9, NUCAPS-IASI, - <u>CrIS</u>	<u>CrIMSS EDR</u>	TES
Cloud Clearing	n/a	Yes	Yes	Yes	No
T/q a-priori	NCEP Climatology	Neural Net	Merra-2	Climatology	AER Product
Trace Gases	n/a	O3, CO, CH4	O3, CO, CH4, CO2, HNO3, N2O, SO2	O3	NH3, CO (single FOV)
Trace gas a-priori	n/a	Climatology	Climatology	Climatology	Climatology
Error estimate	O-E	ECMWF regression	O-E	O-E	O-E
Averaging Kernels	No	No	Yes	No	Yes
Execution Time (per FOR)	?	~1.3 sec/FOR	~200 <u>ms</u> /FOR	?	?
Abbreviations: SVD=Singular Value Decomposition, O-E=Optimal Estimation, FOV=field of view, FOR=field of regard					



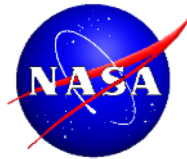
New NASA Science Teams and SIPS for SNPP

- **The Sounder Science Team selected from A.29:**
 - **Chris Barnet** – Team Lead (Standard L2 Products – CrIMSS)
Development and validation of a community hyper-spectral infrared microwave Earth retrieval algorithm: CHIMERA
 - **Hartmut Aumann** (L1 product analysis)
Analysis of the AIRS and CrIS radiometric calibration under cloudy conditions and error propagation into environmental variables
 - **Jean-Luc Moncet** and **Vivienne Payne** (Standard L2 Products – CrIMSS)
Refined Atmosphere Data Products from CrIS and ATMS
 - **Joel Susskind** (Standard L2 Products – CrIMSS)
Analysis of CrIS/ATMS using an AIRS Version 6-like retrieval algorithm
 - **Karen Cady-Pereira** and **Helen Worden** (Specialized L2 Product)
Developing retrieval algorithms for NH₃ and CO from NPP CrIS measurements
 - **Bjorn Lambrigtsen** (Standard L2 Products – ATMS)
Microwave sounder Earth System Data Records

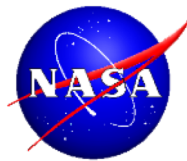


Incorporating New or updated Algorithms

- **When new or updated algorithms become available the following basic process is followed:**
 - **New Algorithm**
 - Establish account on resident SIPS machines (if new team)
 - Algorithm teams ports software to SIPS/JPL and tests in environment
 - SIPS/JPL team writes wrapper code to science code
 - Internal delivery of the code
 - Test data is processed then validated by the science team (iteration point)
 - Software delivered to GES DISC for processing
 - **Changes to Algorithm**
 - Algorithm teams ports updates to SIPS/JPL and tests in environment
 - Internal delivery of the changes
 - Test data is processed then validated by the science team (iteration point)
 - Software delivered to GES DISC for processing



- **There are times when the SIPS distributes data internal to the S-NPP Sounder Science Team for the purpose of characterization, assessment and validation. What is the process?**
 - Such a distribution is announced and discussed at a monthly SNPP Sounder Science Team Meeting led by Chris Barnet
 - Intent and full description of the dataset is discussed
 - Coverage period (amount of data needed)
 - Deficiencies or Liens
 - Contents
 - Location of the dataset is provided by GES DISC by way of a link to an Earthdata login authenticated HTTPS server at the GES DISC

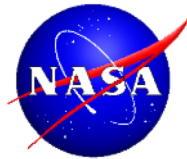


- **Initial Processing Plans**

- Full-mission processing of L1
 - L1 ATMS & L1 CrIS (reduced spectrum) public release planned for May 2017
 - Status:
 - 2016 - 2017 – complete to leading edge
 - 2015 – complete through early May
- L2 & L3 processing (at SIPS/JPL):
 - Several candidate *second-generation* L2 retrieval PGEs will be integrated & tested at SIPS/JPL
 - 8 months of data: 2013 & 2015 Jan, April, July, Oct
 - products delivered to GDAAC for public release
 - *processing occurs at JPL for each algorithm*
– *no processing occurs at GES DISC initially*

- **Forward Processing**

- Level 1 ATMS & CrIS: Processing at a 1x rate
- L0: 26.9 GB/day
- L1: 63.2 GB/day

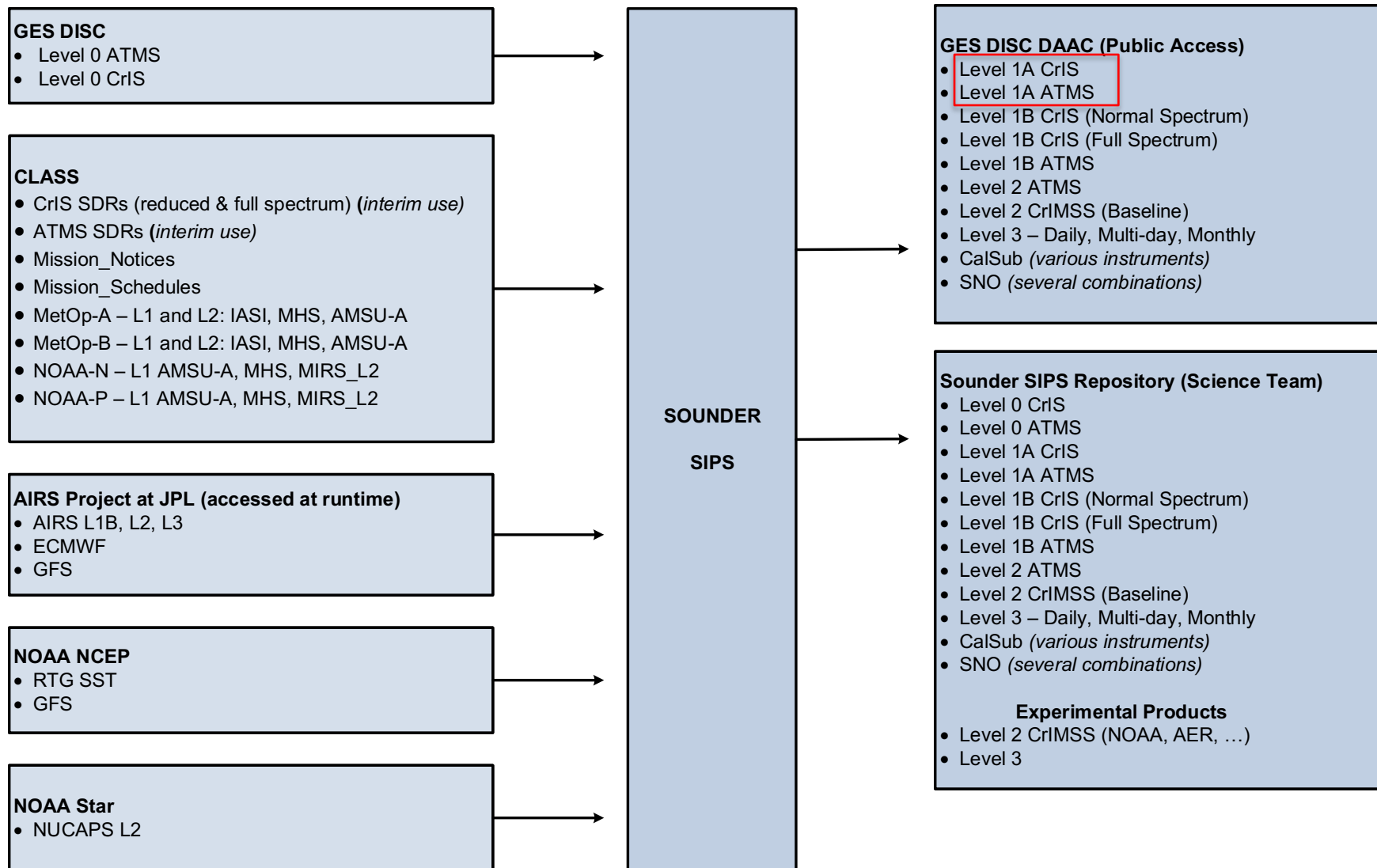


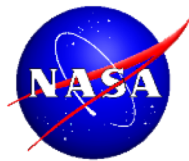
CrIS Level 1 Plans and Status

- **CrIS Level 1 Team:**
 - Joe Taylor and Larrabee Strow (PIs)
 - Collaboration between University of Wisconsin – Madison and University of Maryland, Baltimore County
 - Graeme Martin (Technical Manager)
- **Primary code base being developed at UW (complete PGE)**
 - SNPP Version 1 planned PGE release - May 2017
 - CrIS Normal Spectral Resolution
 - Calibrated radiances
 - Includes CrIS Level 1 Team developed geolocation
 - SNPP Version 2 planned PGE release ~ Spring 2018
 - Updated calibration
 - Incorporates full high-resolution data
 - JPSS-1 Version 2 planned PGE release ~ Spring 2018
 - Support for JPSS-1 implemented
 - SNPP/JPSS-1 Version 3 planned PGE release ~ January 2020
 - Amount of integration needed by JPL is minimal



Data Products Interfaces





Sounder Input Data Stream – Correlative Products

CLASS FTP

- Mission_Notices
- Mission_Schedules
- MetOp-A – (IASI_L1C, AMSUA_L1B, MHS_L1B, MIRS_L2_SND, MIRS_L2_IMG)
- MetOp-B – (IASI_L1C, AMSUA_L1B, MHS_L1B, MIRS_L2_SND, MIRS_L2_IMG)
- MetOp-C* – (IASI_L1C, AMSUA_L1B, MHS_L1B, MIRS_L2_SND, MIRS_L2_IMG)
- NOAA-N (AMSUA_L1B, MHS_L1B, MIRS_L2_SND, MIRS_L2_IMG)
- NOAA-P (AMSUA_L1B, MHS_L1B, MIRS_L2_SND, MIRS_L2_IMG)

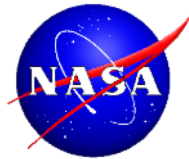
NOAA Star

- NUCAPS Level 2

From archive at JPL

- AIRS: L1B

* - have not yet started to ingest this product.



Sounder SIPS Auxiliary and Ancillary Data

NOAA NCEP

- rtg_sst_g1
- GFS

NOAA PDA (Product Data & Acquisition)

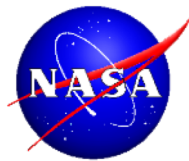
- FNMOC NOGAPS (became NAVGEM on Aug 21, 2013)
(3hr, 6hr 9hr, 12hr, 15hr, 18hr, 21hr 24hr data)

CSpOC/USSTRATCOM (Combined Space Operations Center)

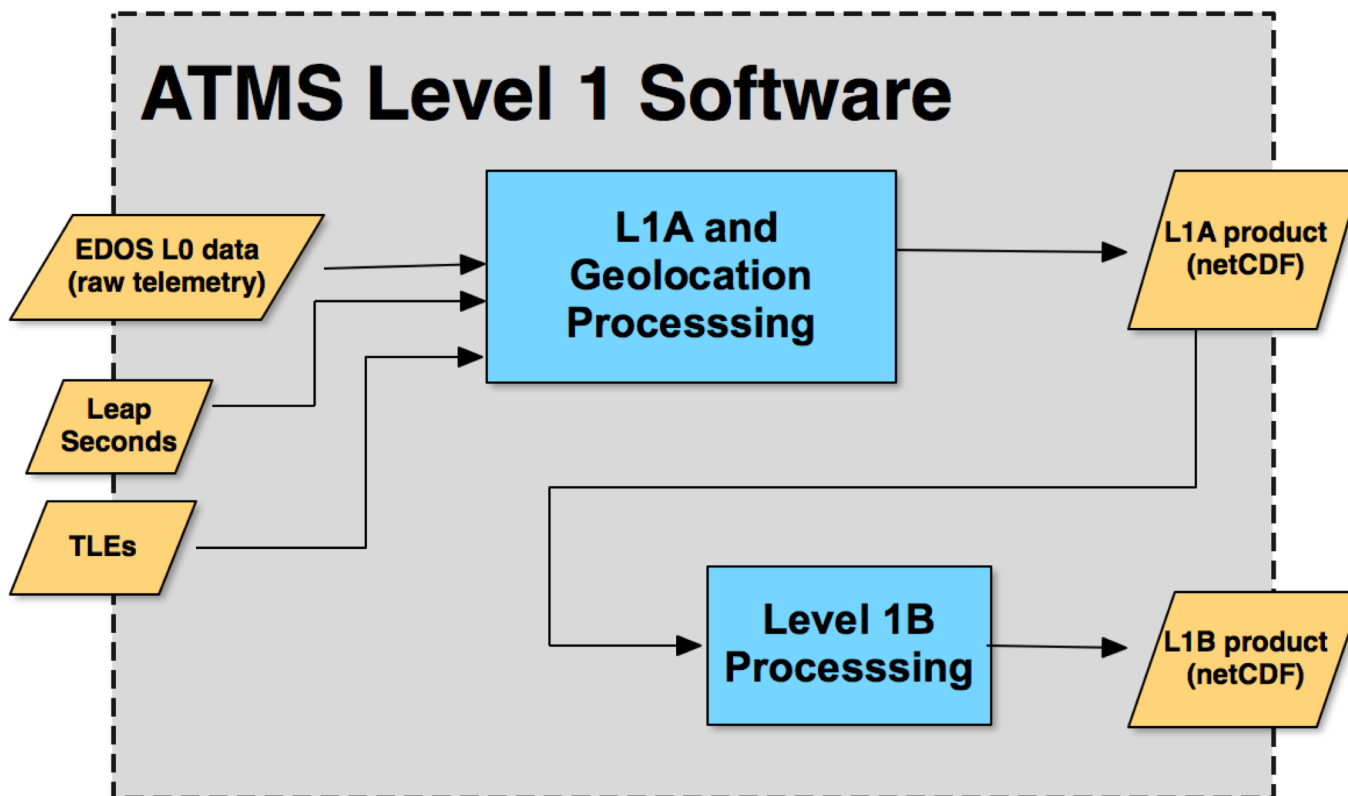
- Two Line Elements (TLEs)

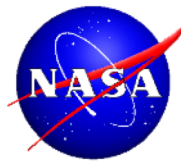
From archives at JPL

- ECMWF – AIRS project
- MERRA – cross-mounted disk from ? project

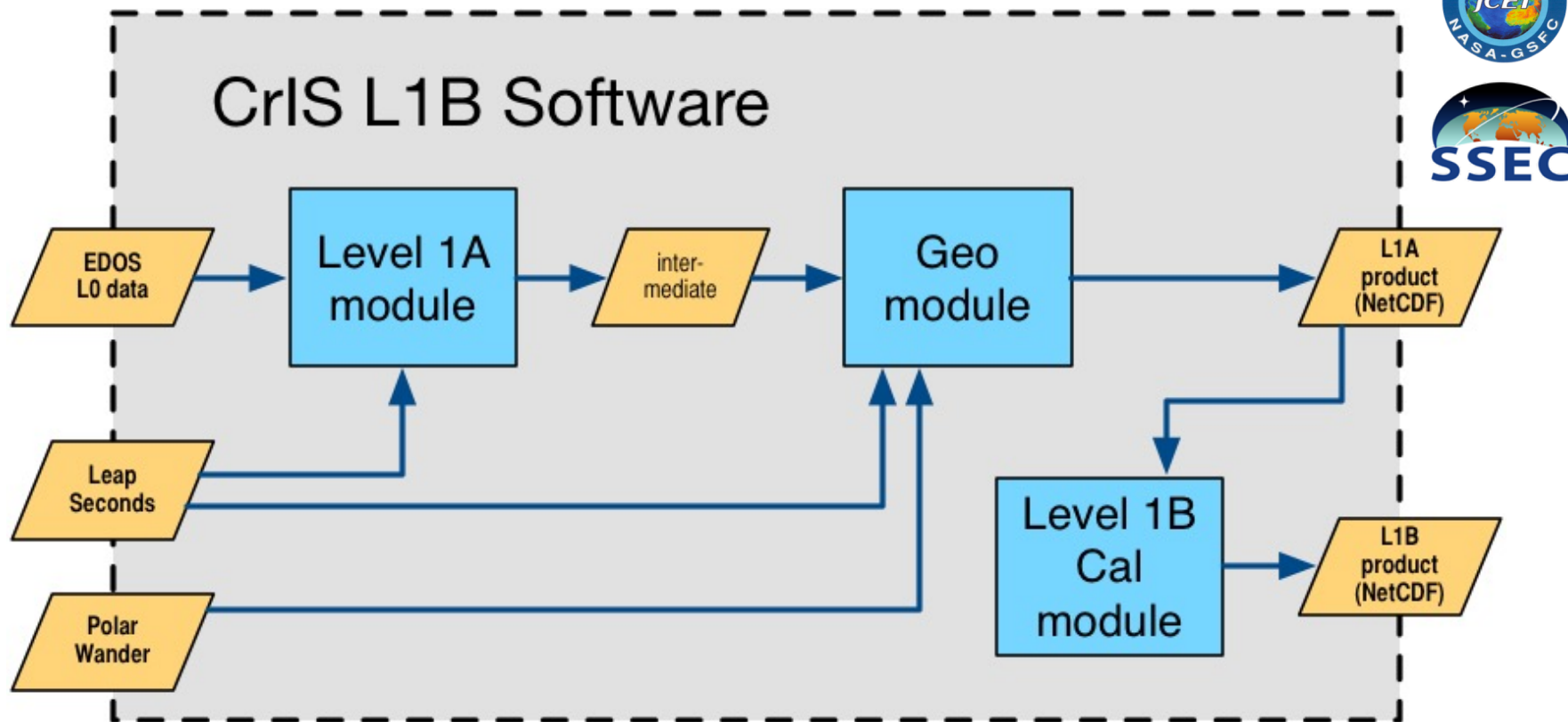


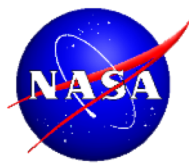
Sounder SIPS Software Flow: ATMS



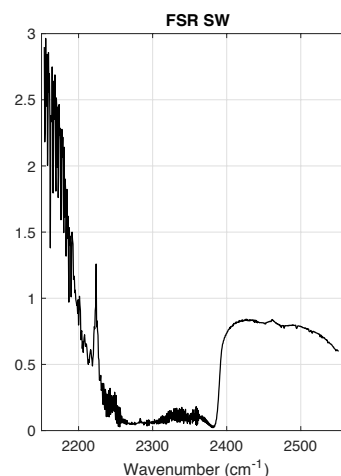
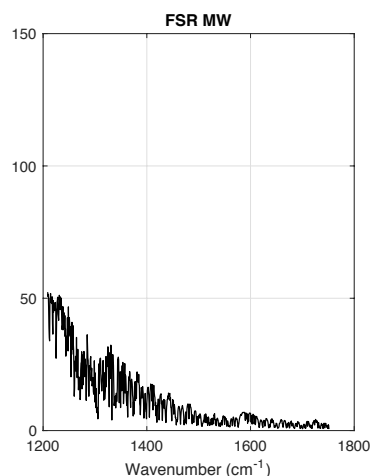
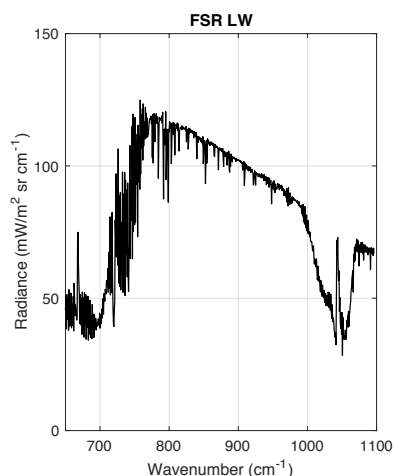
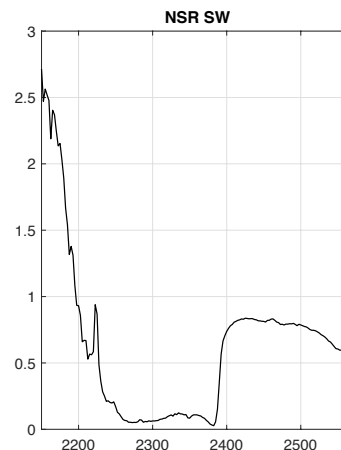
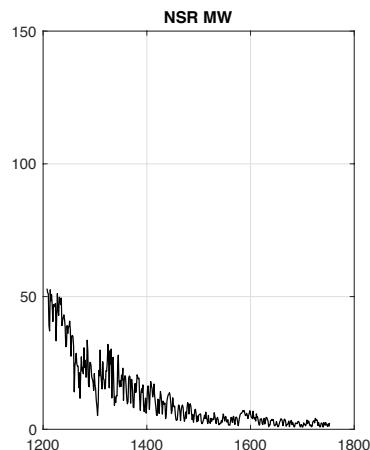
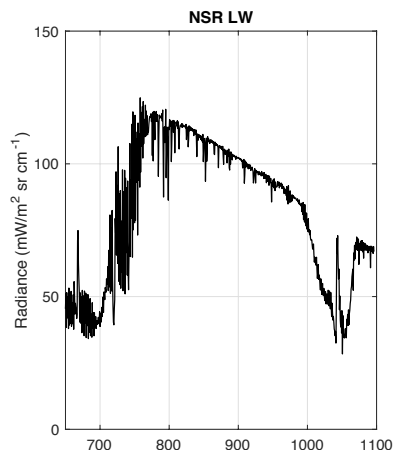


Sounder SIPS Software Flow: CrIS





CrIS NSR vs FSR



FSR:

- 2x better resolution in the MidWave
- Allows better upper troposphere water vapor retrieval

- 4x better resolution in the ShortWave
- Allows retrieval of CO and better calibration of the ShortWave

Channels: 1305 -> 2211